

Brake Pad Partnership Project

Copper Use Monitoring Program
Results for Model Years 1998 - 2006

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Introduction and Purpose

This report contains data on copper use in original equipment¹ automotive friction materials² for the model years 1998 to 2006, which are presented in Table 1. “Friction materials” include disc brake pads (on front and rear brakes) and drum brake linings (on rear brakes only). The Brake Manufacturers Council’s Product Environmental Committee (BMC/PEC) reports annually on the amount of copper in friction materials as a part of its members’ participation in the Brake Pad Partnership.^{3,4}

These data are important to the Brake Pad Partnership for the purposes of:

- (1) monitoring trends in copper use over the course of the Partnership, and monitoring the industry’s voluntary reduction in use of copper in the event the Partnership determines that copper from friction materials is a significant cause of water quality impairment; and
- (2) providing inputs for modeling studies of the environmental fate and transport of automotive friction material wear debris in the environment.

Data Strengths and Limitations

- **Best available data set.** These are the most comprehensive and reliable data available regarding the copper content of automotive friction materials in the United States. They are reported voluntarily by the BMC/PEC as a part of its members’ participation in the Brake Pad Partnership, and would not be collected and made publicly available without the Partnership’s cooperative approach.
- **Data are for approximately 40% of new automobiles.** The data for model years 1998 to 2001 are reported for the copper content of vehicle friction materials for the top 20 best-selling vehicles, which comprise approximately 40% of the new cars and light trucks sold in the United States. For model years 2002 to 2006, data were not available for all of the top 20 best-selling vehicles. The sample used for model year 2002 includes 20 of the top 25 best-selling vehicles for which data were available, which comprises 39% of the new cars and light trucks sold in the United States for that model year. The sample used for model year 2003 includes 23 of the top 25 best-selling vehicles for which data were available, which comprises 42% of the new cars and light trucks sold in the United States for that model year. The sample used for model year 2004 includes 22 of the top 25 selling vehicles for which data were available, which comprises 39% of the new cars and light trucks sold in the United States for that model year. The sample used for model year 2005 includes 23 of the top 25 best-selling vehicles for which data were available,

¹ “Original equipment” refers to equipment that comes on new vehicles, and does not include “aftermarket” or replacement parts.

² “Automotive friction materials” refers to friction materials used in cars and light trucks, and does not include friction materials used on heavy-duty trucks, off-road vehicles, or motorcycles.

³ The Brake Pad Partnership is a collaborative effort to understand the impacts on the environment that may arise from brake pad wear debris generated in the use of passenger vehicles. Working together, manufacturers, regulators, stormwater management agencies, and environmentalists developed an approach for evaluating potential impacts on water quality, using copper in the South San Francisco Bay as an example. Friction material manufacturers have committed to adding this evaluation approach to their existing practices for designing products that are safe for the environment while still meeting the performance requirements demanded of these important safety-related products.

⁴ The data reported herein were originally reported in: Anderson, Richard. “Friction Material Content Monitoring: A Project of the BMC Product Environmental Committee.” Motor and Equipment Manufacturers Association, Research Triangle Park, North Carolina. December 20, 2007.

which comprises 38% of the new cars and light trucks sold in the United States for that model year. The sample used for model year 2006 includes the top 25 best-selling vehicles for which data were available, which comprises 35% of the new cars and light trucks sold in the United States for that model year.

- **Trend indicator.** The data indicate the industry trend in use of copper in friction materials. The data do not provide the total amount of copper used in friction materials in the vehicle fleet.
- **Data are not designed for mass load calculations.** These data are not intended nor are they appropriate for calculating total copper loadings to the environment from friction materials on a national, regional, or local scale. While the data represent a significant sample of new vehicles, they encompass less than half of the friction materials in new vehicles. Copper use in other vehicles and vehicle sectors and in the aftermarket is likely to differ significantly from that reported here for the top selling new vehicles. Within a region or watershed, variations in fleet mix and vehicle use patterns also contribute to differences in copper content and amounts of wear debris released to the environment. It is important to note that not all of the copper in friction materials is released to the environment. Friction material ingredients can wear out of a pad or lining at different rates, and brake pads and linings are normally replaced with a considerable amount of the friction material still intact.
- **Actual copper content.** The data are based on manufacturers' reporting of the actual copper content of their products. These data are collected and made available by the BMC/PEC in a manner that protects manufacturers' confidential business information, including the copper content of friction materials on specific new vehicles and the name of the manufacturer that supplies the friction materials.
- **Actual vehicle sales data.** The data reflect actual sales for each model year.
- **Vehicle fleet mixes vary.** The data do not reflect regional variations in vehicle fleet mixes.
- **Aftermarket (replacement) brake pads and linings are not included.** The data are for "original equipment" friction materials only. "Original equipment" refers to parts that are installed on new vehicles. It does not include "aftermarket" or replacement parts. The BMC/PEC has stated that the copper content of aftermarket friction materials is small, but no public data are available to confirm that statement.
- **Heavy-duty trucks, off-road vehicles, and motorcycles are not included.** These data are for friction materials used in cars and light trucks. The data do not include friction materials used on heavy-duty trucks, off-road vehicles, or motorcycles. Manufacturers of these other friction material types are not currently participating in the Brake Pad Partnership.

Data Collection and Reporting Process

The Brake Manufacturers Council's Product Environmental Committee (BMC/PEC) consists of the majority of companies that manufacture original equipment friction materials for automotive vehicles manufactured in the United States, Canada, and Mexico for sale in the United States. The BMC/PEC has developed a process for collecting and reporting these data that produces accurate information while maintaining the confidentiality of its member companies' proprietary business information.

The data reported here represent the amount of copper and friction material used on samples of the most popular vehicles sold in the United States, by model year, comprising approximately 40% of the total U.S. sales of domestic automobiles.

Sample Selection

The samples selected for data collection were from the top best selling domestic cars and light trucks for each model year. All data on actual vehicle sales were obtained from the *Ward's Automotive Yearbooks*.⁵ For model years 1998 to 2001, the top 20 best selling vehicles were selected comprising about 40% of the total vehicle sales for each year. The list of the Top 20 best selling vehicles for model years 1998 through 2001 and their sales volumes are shown in Table 2.

For model years 2002 to 2006, data were not available for some of the top 20 best selling vehicles, and the sampling method was modified to include available data on the top 25 best selling vehicles to obtain a sample comprising approximately 40% of the total vehicle sales for the year. Table 3 lists the vehicles sampled for model years 2002 through 2006. Those vehicles for which volumes are listed in the "processed" column are the ones for which copper use data were available. Those vehicles for which check marks appear in the "calculated" column are ones that may be purchased with a choice of different brake systems. The sample includes only those vehicles having disc brake systems.

Data Collection

Each year, data are requested from each of the BMC/PEC member companies on the friction materials supplied for each of the vehicle makes and models on the list of top selling vehicles. Specifically, information is requested for the make and model to which the manufacturers supplied in January of the model year.

A copy of the information request form used is contained in Appendix B. The specific information requested of and reported by the manufacturers included:

- the weight of the friction material for one axle set (front and rear reported separately),
- the total copper by weight in the friction material for one axle set, and
- the percentage of the model production for which the data are applicable.

Data Aggregation

The BMC/PEC process for collecting and reporting these data is designed to provide high-quality, accurate information while maintaining the confidentiality of its member companies' proprietary business information. Several checks are built into the process. At least two individuals review and confirm the annual list of top selling vehicles. Data are entered into an electronic spreadsheet from the reporting forms submitted by the manufacturers, and then checked for accuracy by two other individuals. Once the data have been recorded and checked, the spreadsheet is locked so that it cannot be altered accidentally, and the original information is destroyed to protect the manufacturers' proprietary business information.

⁵ 1999 Ward's Automotive Yearbook, 61st Edition. Ward's Communications, Detroit. Pp. 246-248.
2000 Ward's Automotive Yearbook, 62nd Edition. Ward's Communications, Detroit. Pp. 244-246.
2001 Ward's Automotive Yearbook, 63rd Edition. Ward's Communications, Detroit. Pp. 249-251.
2002 Ward's Automotive Yearbook, 64th Edition. Ward's Communications, Detroit. Pp. 243-245.
2003 Ward's Automotive Yearbook, 65th Edition. Ward's Communications, Detroit. Pp. 234-236.
2004 Ward's Automotive Yearbook, 66th Edition. Ward's Communications, Detroit. Pp. 244-246.
2005 Ward's Automotive Yearbook, 67th Edition. Ward's Communications, Detroit. Pp. 243-245.
2006 Ward's Automotive Yearbook, 68th Edition. Ward's Communications, Detroit. Pp. 234-236.
2007 Ward's Automotive Yearbook, 69th Edition. Ward's Communications, Detroit, Pp. 244-246.

The data are analyzed using calculation formulas on the spreadsheet that are also locked to prevent accidental errors. Upon completion of the data analysis, they are checked by one other individual, and the entire spreadsheet is locked to prevent further changes.

The resultant aggregated data, combined with the actual annual sales volume numbers from *Ward's Automotive Reports*, contains information on the total friction material and copper use for the sample for each model year. These data are reported in Table 1.

TABLE 1. Friction Material Copper Content Monitoring Results⁴

Model Year:	<u>1998</u>	<u>1999</u>	<u>2000</u>	<u>2001</u>	<u>2002</u>	<u>2003</u>	<u>2004</u>	<u>2005</u>	<u>2006</u>
<u>Top Selling Vehicle Samples⁶</u>									
Total vehicle sales (vehicles)	15,540,765	16,890,536	17,349,760	17,122,368	16,816,368	16,639,053	16,866,920	16,947,754	16,504,400
Top 20 vehicle sales (vehicles)	6,659,538	6,931,931	6,810,814	6,799,008	--	--	--	--	--
Sample vehicle sales	--	--	--	--	6,633,977	7,011,419	6,535,136	6,450,906	5,705,459
Percent of total vehicle sales	42.8%	41.0%	39.3%	39.7%	39.4%	42.1 %	38.7%	38.1%	34.6%
Friction material in Top 20 (kg)	9,366,940	9,109,322	8,556,864	8,416,727	--	--	--	--	--
Friction material in Sample 20 (kg)	--	--	--	--	7,850,371	8,142,643	8,112,754	7,779,893	6,081,554
Friction material per vehicle (kg)	1.406	1.314	1.256	1.238	1.183	1.161	1.241	1.206	1.066
Cu in Top 20 (kg)	267,462	358,541	384,145	381,507	--	--	--	--	--
Cu in Sample (kg)	--	--	--	--	507,938	538,992	424,780	427,365	498,225
Cu per vehicle (kg)	0.0402	0.0517	0.0564	0.0561	0.0766	0.0769	0.0650	0.0662	0.0873

⁶ A list of the top 20 best-selling vehicles for each model year from 1998 to 2001 is included in Table 2, and a list of the top 25 best-selling vehicles sampled for model years 2002 through 2006 is included in Table 3.

TABLE 2. Top 20 Best-Selling Vehicles and Actual Sales for Model Years 1998 through 2001.

<u>Segment, Make and Model</u>	<u>Actual Sales</u>			
	1998	1999	2000	2001
<i>Small Car</i>	5.1%	4.6%	7.1%	7.1%
Chevrolet Cavalier	256,099	272,122	236,803	233,298
Ford Escort	291,936	260,486	n/a	n/a
Ford Focus	n/a	n/a	286,166	264,414
Saturn	n/a	n/a	177,355	162,110
Toyota Corolla	250,500	249,128	230,156	245,023
Honda Civic	n/a	n/a	306,748	311,314
Segment total	798,535	781,736	1,237,228	1,216,159
<i>Middle Car</i>	11.3%	10.5%	8.2%	9.2%
Chevrolet Malibu	223,703	218,540	207,376	176,583
Honda Civic	317,134	308,807	n/a	n/a
Pontiac Grand Am/Oldsmobile Alero ⁷	180,428	234,936	214,923	291,348
Ford Taurus/Mercury Sable ⁸	371,074	368,327	382,035	456,206
Honda Accord	370,984	316,339	317,483	350,090
Toyota Camry	295,108	320,156	298,123	303,436
Segment total	1,758,431	1,767,105	1,419,940	1,577,663
<i>Sport Utility Vehicle (SUV)</i>	7.4%	7.4%	7.3%	5.2%
Chevrolet Blazer	219,710	232,140	255,948	n/a
Ford Explorer/Mercury Mountaineer	479,083	478,003	491,704	461,495
Jeep Grand Cherokee	229,135	300,031	271,723	223,612
Ford Expedition/Lincoln Navigator	225,703	233,125	251,406	209,804
Segment total	1,153,631	1,243,299	1,270,781	894,911
<i>Van/Small Pickup</i>	6.8%	6.3%	5.6%	5.8%
Dodge Caravan/Plymouth Voyager/Chrysler Voyager	450,790	431,744	384,561	287,481
GMC Sonoma/S10	282,912	291,661	262,680	204,243
Ford Ranger/Mazda ⁹	328,136	348,358	330,125	298,591
Ford Windstar/Mercury Voyager	n/a	n/a	n/a	201,641
Segment total	1,061,838	1,071,763	977,366	991,956
<i>Large Pickup</i>	12.1%	12.2%	11.2%	12.4%
Chevrolet Silverado/GMC Sierra	235,110	734,234	734,377	908,629
Chevrolet and GMC C/K	454,311	98,285	n/a	n/a
Dodge Ram	410,130	428,930	380,874	344,538
Ford F-series	787,552	806,579	820,248	865,152
Segment total	1,887,103	2,068,028	1,935,499	2,118,319
Total Top 20 vehicle sales	6,659,538	6,931,931	6,810,814	6,799,008
Percent of total vehicle sales	42.8%	41.0%	39.3%	39.7%
Total vehicle sales	15,540,765	16,890,536	17,349,760	17,122,368

⁷ Starting 2001 includes Oldsmobile Alero.⁸ Starting 2001 includes Mercury Sable.⁹ Starting 2001 includes Mazda.

n/a (not applicable): This vehicle not in top 20 best-selling vehicles for corresponding model year.

TABLE 3. Sample Selection for Model Years 2002 through 2006

Segment/Vehicle	Volume (number of vehicles)					
	Selected ¹⁰	2002 Processed ¹¹	Calculated ¹²	Selected ¹⁰	2003 Processed ¹¹	Calculated ¹²
Small Cars:						
Honda Civic	283,173	283,173		260,632	260,632	
Chevrolet Cavalier	238,225	0		256,550	256,550	✓
Ford Focus	243,199	243,199		229,353	229,353	
Toyota Corolla	222,017	222,017	✓	265,449	265,449	✓
Middle Cars:						
Toyota Camry	343,796	343,796		367,394	367,394	
Ford Taurus/Mercury Sable	431,688	431,688		361,838	361,838	
Honda Accord	330,692	330,692		325,465	325,465	✓
Pontiac Grand Am/Oldsmobile Alero	245,103	0		255,589	0	
Chevrolet Impala	198,918	0		267,882	0	
Nissan Altima	201,822	201,822	✓	201,240	201,240	✓
Chevrolet Malibu	169,377	0		173,263	173,263	✓
CUVs:						
PT Cruiser/Dodge Neon/Plymouth Neon	264,817	264,817		227,860	227,860	
SUVs:						
Large GMC SUVs (e.g., Tahoe/Suburban)	540,981	540,981		527,033	527,033	
Ford Explorer/Mercury Mountaineer	481,991	481,991		422,810	422,810	
Chevrolet TrailBlazer/Oldsmobile Bravada/GMC Envoy	374,625	374,625		397,168	397,168	
Jeep Grand Cherokee	224,233	224,233		207,479	207,479	
Ford Escape/Mazda Tribute	190,460	0		217,190	217,190	✓
Ford Expedition/Lincoln Navigator	194,067	194,067	✓	220,289	220,289	✓
Jeep Liberty	n/a	n/a	n/a	162,987	162,987	
Van/Small Pickup:						
DC Minivans (e.g., Caravan/Voyager/Town & County)	408,681	408,681	✓	374,494	374,494	
Ford Ranger/Mazda Pickup	246,359	246,359		224,087	224,087	
Chevrolet S10/GMC Sonoma	192,092	192,092		171,613	171,613	
Ford Windstar/Mercury Villager	165,317	165,317	✓	n/a	n/a	n/a
Large Pickup:						
Chevrolet Silverado/GMC Sierra	847,894	847,894		880,318	880,318	
Ford F-Series	774,037	774,037		806,887	806,887	
Dodge Ram Pickup	396,934	396,934	✓	449,371	449,371	
Total Volume of Sample:	8,210,498	7,168,415	6,633,977	8,254,241	7,730,770	7,011,419
Total Volume:	16,816,368	16,816,368	16,816,368	16,639,053	16,639,053	16,639,053
Percentage:	49%	43%	39%	49.6%	46.5%	42.1%

¹⁰ Includes all of the top 25 best selling vehicles.

¹¹ Includes the top 25 best selling vehicles for which copper use data are available.

¹² Indicates vehicles available with different brake systems. Includes only vehicles having disc brake systems.

n/a (not applicable): This vehicle not in the top 25 best-selling vehicles for corresponding model year.

TABLE 3. Sample Selection for Model Years 2002 through 2006 (continued)

Segment/Vehicle	Volume (number of vehicles)					
	Selected ¹⁰	2004 Processed ¹¹	Calculated ¹²	Selected ¹⁰	2005 Processed ¹¹	Calculated ¹²
Small Cars:						
Honda Civic	274,540	274,540	✓	263,833	263,833	✓
Chevrolet Cavalier	195,275	0		231,672	0	
Ford Focus	208,339	208,339		184,825	184,825	
Toyota Corolla	306,510	306,510	✓	330,782	330,782	✓
Middle Cars:						
Toyota Camry	402,063	402,063		402,887	402,887	
Ford Taurus/Mercury Sable	290,885	290,885	✓	221,068	221,068	✓
Honda Accord	325,925	325,925	✓	350,257	350,257	✓
Chevrolet Impala	290,259	0		246,481	0	
Nissan Altima	235,889	235,889	✓	255,371	255,371	✓
Chevrolet Malibu	268,017	268,017	✓	245,861	245,861	✓
CUVs:						
PT Cruiser/Dodge Neon/Plymouth Neon	213,435	213,435		229,220	229,220	✓
SUVs:						
Large GMC SUVs (e.g., Tahoe/Suburban)	495,188	495,188	✓	396,302	396,302	
Ford Explorer/Mercury Mountaineer	383,249	383,249		272,279	272,279	
Chevrolet TrailBlazer/Oldsobile Bravada/GMC Envoy	420,354	420,354		352,339	352,339	
Jeep Grand Cherokee	182,313	0		213,584	213,584	
Ford Escape/Mazda Tribute	224,508	224,508	✓	201,883	201,883	✓
Ford Expedition/Lincoln Navigator	196,244	196,244		139,981	139,981	
Jeep Liberty	167,376	167,376		166,883	166,883	
Van/Small Pickup:						
DC Minivans (e.g., Caravan/Voyager/Town & County)	369,330	369,330	✓	407,530	407,530	✓
Ford Ranger/Mazda Pickup	166,588	166,588		126,830	126,830	
Econoline Club Wagon	171,017	171,017		179,543	179,543	
Toyota Sienna	159,119	159,119		161,380	161,380	
Large Pickup:						
Chevrolet Silverado/GMC Sierra	894,399	894,399		935,468	935,468	
Ford F-Series	891,482	891,482		854,878	854,878	
Dodge Ram Pickup	426,289	426,289		400,543	400,543	
Total Volume of Sample:	8,185,593	7,517,746	6,535,136	7,771,680	7,293,527	6,450,906
Total Volume:	16,866,920	16,866,920	16,866,920	16,947,754	16,947,754	16,947,754
Percentage:	49%	45%	39%	46%	43%	38%

TABLE 3. Sample Selection for Model Years 2002 through 2006 (continued)

Segment/Vehicle	Volume (number of vehicles)		
	Selected ¹⁰	2006 Processed ¹¹	Calculated ¹²
Small Cars:			
Honda Civic	272,899	272,899	✓
Chevrolet Cobalt	211,804	211,804	✓
Ford Focus	177,006	177,006	✓
Toyota Corolla/Matrix	335,054	335,054	✓
Middle Cars:			
Toyota Camry	362,961	362,961	
Ford Taurus/Mercury Sable	174,803	174,803	✓
Honda Accord	323,079	323,079	✓
Chevrolet Impala	289,868	289,868	
Nissan Altima	232,457	232,457	✓
Chevrolet Malibu	163,853	163,853	✓
CUVs:			
PT Cruiser (formerly included Neon)	143,387	143,387	✓
Ford Escape/Mazda Tribute	184,180	184,180	✓
SUVs:			
Large GMC SUVs (e.g., Tahoe/Suburban)	394,608	394,608	
Ford Explorer/Mercury Mountaineer	208,796	208,796	✓
Chevrolet TrailBlazer/GMC Envoy	249,249	249,249	
Jeep Grand Cherokee	139,148	137,757	✓
Jeep Liberty	133,557	133,557	
Van/Small Pickup:			
DC Minivans (e.g., Caravan)	370,245	370,245	
Honda Odyssey	177,919	177,919	✓
Ford Econoline/Club Wagon	180,457	180,457	
Toyota Sienna	163,269	163,269	✓
Toyota Tacoma	178,351	178,351	✓
Large Pickup:			
Chevrolet Silverado/GMC Sierra	846,805	846,805	✓
Ford F-Series	744,996	744,996	
Dodge Ram Pickup	364,177	364,177	✓
Total Volume of Sample:	7,022,928	7,021,537	5,705,459
Total Volume:	16,504,400	16,504,400	16,504,400
Percentage:	42.6%	42.54%	34.57%

APPENDIX A

Vehicle Segment Definitions Used in *Ward's Automotive Yearbook*

<u>Segment</u>	<u>Typical Price range</u>	<u>Typical Length</u>
<u>Small Cars</u>		
Lower Small Car	\$11,500 and under	Under 175 inches
Upper Small Car	\$11,501 to \$17,999	Under 180 inches
Small Specialty Car	Under \$18,000	Under 180 inches
<u>Middle Cars</u>		
Lower Middle Car	\$14,500 to \$18,499	180 to 190 inches
Upper Middle Car	\$18,500 to \$24,999	180 to 190 inches
Middle Specialty Car	\$14,500 to \$24,900	180 to 199 inches
<u>Large Cars</u>		
Large Car	Under \$25,000	Over 200 inches
<u>Luxury Cars</u>		
Lower Luxury Car	\$25,000 to \$32,999	-
Middle Luxury Car	\$33,000 to \$43,999	-
Upper Luxury Car	\$44,000 plus	-
Luxury Specialty Car	\$25,000 plus	-
Luxury Sport Car	\$25,000 plus	-
<u>Cross Utility Vehicles (CUV)</u>		
Small CUV	Under \$20,000	Under 180 inches
Medium CUV	\$20,000 to \$30,000	180 to 190 inches
Large CUV	\$30,000 plus	Over 190 inches
<u>Sport Utility Vehicles (SUV)</u>		
Small SUV	Under \$20,000	Under 170 inches
Middle SUV	Under \$30,000	170 to 192 inches
Middle Luxury SUV	\$30,000 plus	170 to 192 inches
Large SUV	Under \$40,000	Over 192 inches
Large Luxury SUV	\$40,000 plus	Over 192 inches
<u>Vans</u>		
Small Van	Under \$26,000	Under 210 inches
Large Van	Under \$26,000	210 inches plus
Luxury Van	\$26,000 plus	-
<u>Pickup Trucks</u>		
Small Pickups	\$14,000 and under	Under 200 inches
Large Pickups	Above \$14,000	200 inches plus

APPENDIX B

Sample Information Request Form

**Product Environmental Committee
Friction Material Monitoring**

CONFIDENTIAL

*This information is for the exclusive
use of the Brake Manufacturers Council*

- Directions:
1. Identify brake manufacturer, e.g., Delphi.
 2. Check the model year(s) applicable to the data.
 3. List the make and model. (Example: Ford Ranger)
 4. Report the axle set weights in gms.
Friction material weight is without steel, etc.
Copper content is for the axle set [*See instructions*].
2. Please fill in all blanks (use NA for "not applicable").
 3. Return by fax, mail, or e-mail.

Manufacturer: _____

Model year (s): 02 03

Make & Model: _____

Front axle: Friction _____ **gms. Copper** _____ **gms. {Note 1}**

Percentage of model _____ **Example: May be different materials
with or without ABS**

Rear axle: Friction _____ **gms. Copper** _____ **gms. {Note 1}**

Percentage of model _____

***PERCENTAGE OF MODEL MUST BE FILLED IN FOR FRONT AND/OR REAR AXLES!**

Note 1. The copper level in storm water is determined by atomic adsorption on unfiltered storm water. The water sample is treated with nitric acid to digest all forms of copper.

Factors for calculating net copper content in various copper containing additives are:

- Brass: Typical copper content is 70.0 wt%, but may vary with the type of brass.
- Copper oxide (Cu₂O): 88.8 wt% copper
- Copper oxide (CuO): 79.9 wt% copper
- Copper sulfide (Cu₂S): 79.9 wt% copper
- Copper sulfide (CuS): 66.5 wt% copper

REPORT THE NET %

(Same process as used for 2000 and 2001)

Return to: Brake Council Project Administrator
10 Laboratory Drive
Research Triangle Park, NC 27709-3966

FAX: 919-406-1306

E-mail: pbecoat@mema.org